Simulation for Research, Development, and Test of Battlefield Intelligent Agents

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Introduction

- Situation understanding and adaptivity are crucial to success in the modern battlespace
- Cyber warfare, unprecedented amounts of information, and rapid changes in information make situation understanding and adaptivity increasingly difficult
- The cyber warfare environment is one of the most challenging decision-making environments due to the volume of data and pace of data change
- Development of intelligent agents and decision-support systems remains difficult
  - Must be robust, resilient, and capable of shielding the user from cognitive attack
- The user must develop SA via their own efforts
  - The utility of an intelligent agent is its ability to winnow information and minimize the user's SA challenges
  - Users must be trained so that they are prepared for the information environment they will face
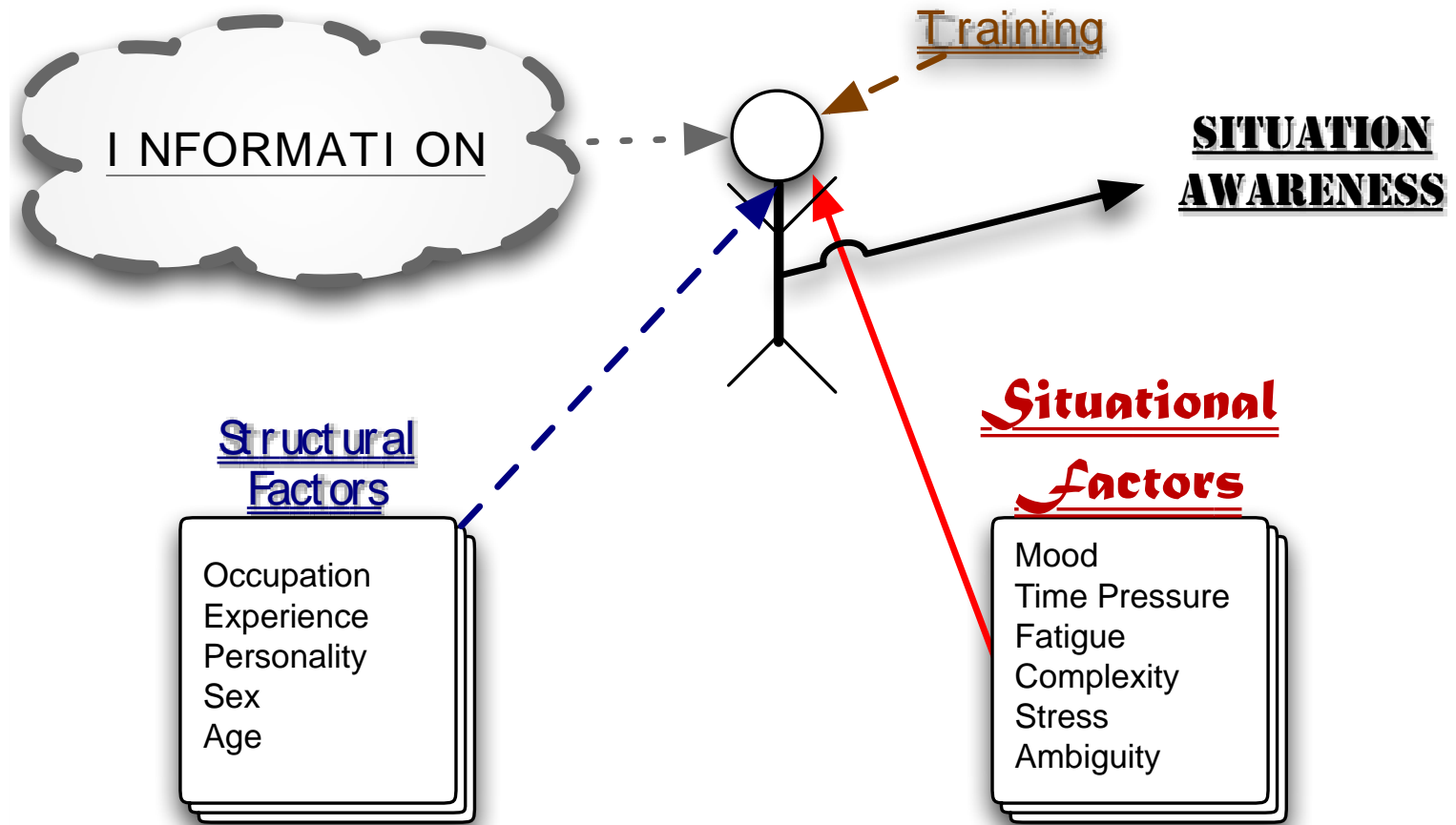- Our goal is to develop faster means for developing more useful intelligent agents

Background

- To improve user situational awareness, the intelligent agent must
  - Minimize user taskload
  - Allow users to concentrate on the significant aspects of the battlespace
- Situational awareness (Endsley)
  - Perception of the elements in an environment
  - Comprehension of the elements' meaning
  - Projection of the elements' state into the future
  - Prediction of how various actions will affect fulfillment of goals
- Mental model of a rapidly changing environment
  - Assembled over time and continuously updated
- Not a passive activity; continuous mental exercise

Background

- The SA challenge faced by the decision-maker lies in assembling the elements of the environment into a pattern
  - SA is time, mission, and role dependent
- Four components of SA (Endsley)
  - Perception, comprehension, projection, and prediction
  - Perception is mediated by goals and experiences; not just data awareness
    - User must develop and maintain a mental model
  - The user conducts all four activities concurrently
    - Multiple situations; each changing at its own rate
- Cyber attacks undercut SA development by corrupting data as well as by corrupting the perceived effect of action

Situational Awareness

Training

INFORMATION

SITUATION AWARENESS

Structural Factors

Occupation
Experience
Personality
Sex
Age

Situational Factors

Mood
Time Pressure
Fatigue
Complexity
Stress
Ambiguity

SA Can Be Undermined

Full power, rocking wings (stall warning), steady heading, pitch 15 degrees up, descending at 10,000 FPM. Its dark, over ocean, in cloud, with cockpit alarms sounding. The intelligent aid says to increase pitch …

Situation Awareness Cycle
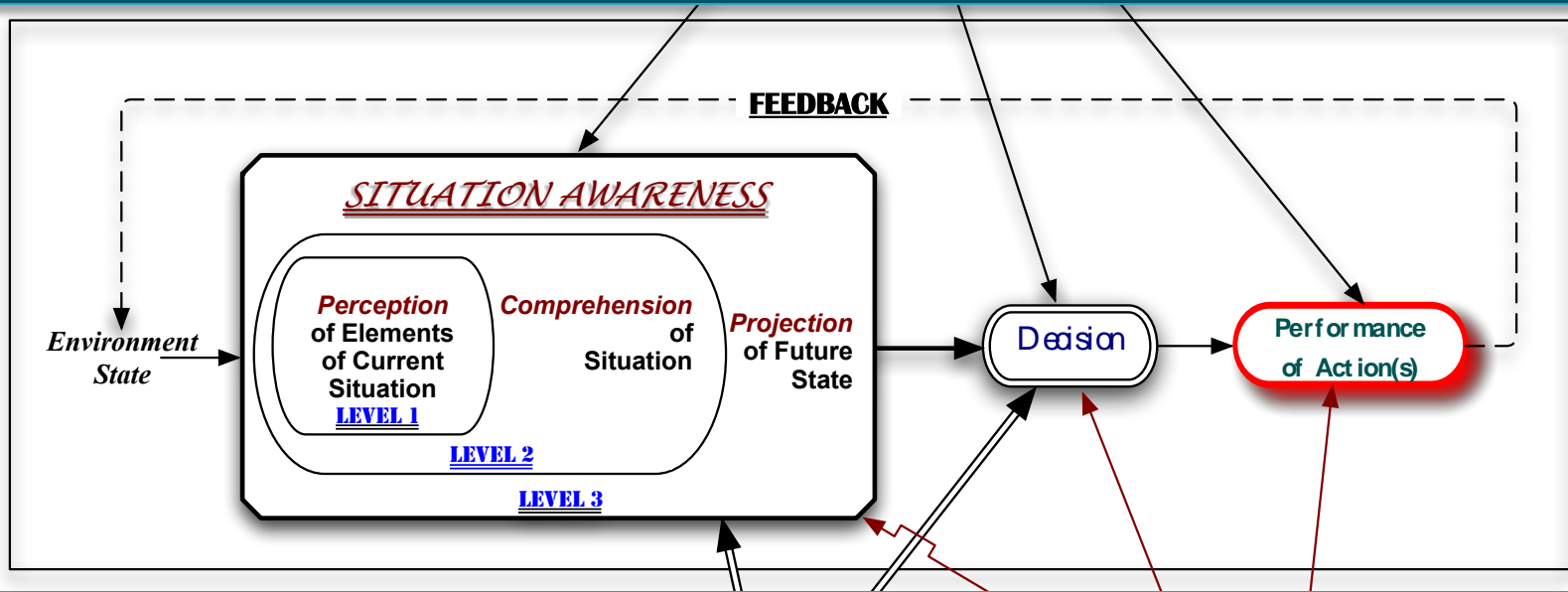
Intelligent Agents

- Assist the user in understanding both real-world and cyber battlespaces
- Architecture and design may be similar; knowledgebase content is different
- Used to assess security, accuracy, and relevance of information and in all phases of SA development
  - Must be adaptable to the capabilities of the decision-maker
- Should anticipate decision-maker information needs
- Estimate decision-maker intent, objectives, and plans
- Provide ubiquitous, transparent, intuitive <u>help</u>

Intelligent Agent Roles

- Intelligent agents should act to remove questionable information
- Help user retrieve information upon demand and in anticipation of needs
- Intelligent agents should act cooperatively to assist the user
  - A team
- Intelligent agents should present alternative courses of action
- Requires numerous, very large databases

Using Simulation

- To develop the knowledge bases required by the intelligent agents, we propose using simulation environments
- Subject matter experts (SMEs) are used as appropriate to build foundational knowledge bases
- Knowledge bases are built using successive refinement
  - Use the SMEs to evaluate performance of knowledge bases
  - Use data mining to evaluate and rank knowledge base alternatives
  - Use data mining and SMEs to evaluate intelligent agent performance by comparing outcomes
  - Not looking for an absolute best, just relative useful improvement

Using Simulation

- To develop the knowledge bases, we improve them one at a time
  - Each intelligent agent uses one knowledge base
- Scenarios executed within simulation environment
  - Use scenarios to describe a refinement pass, multiple passes performed
  - When evaluation indicates that a knowledge base & intelligent agent pair has peaked in performance
    - The knowledge base is frozen
    - Another knowledge base & intelligent agent pair is selected and refined

Knowledgebase Development
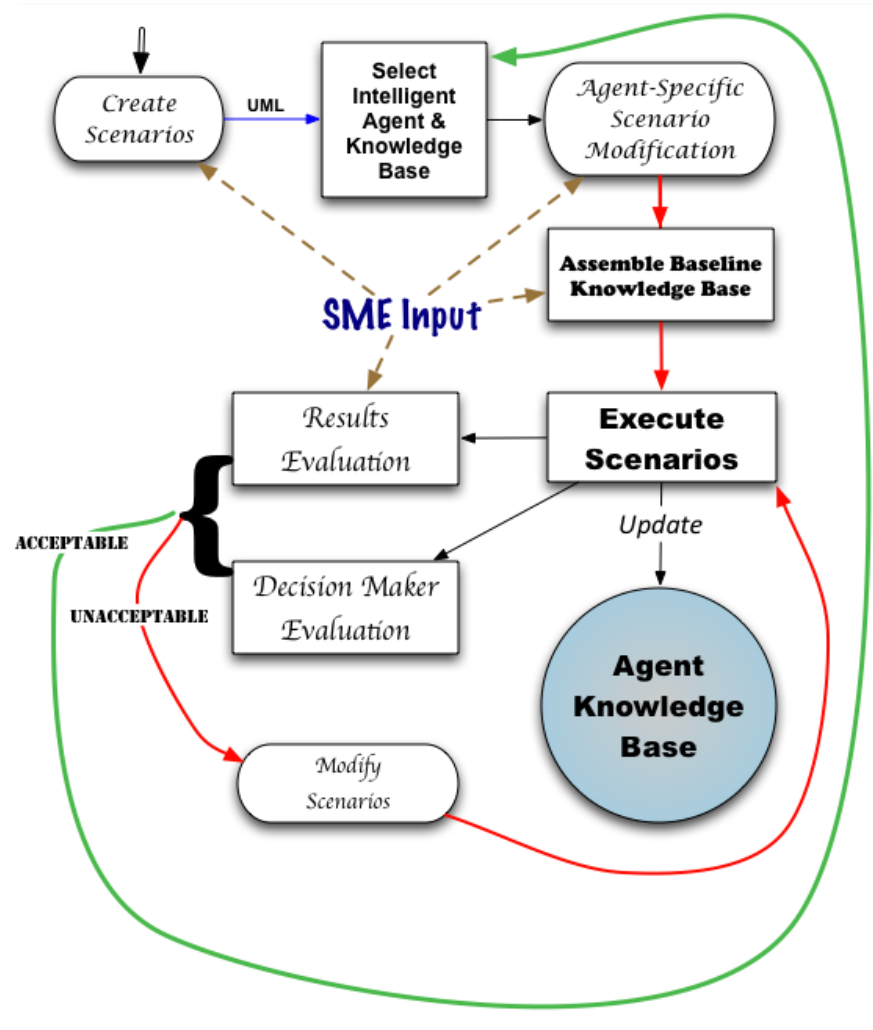
Intelligent Agent Structure

- Factor intelligent agents along functionality, user/decision support, and situational awareness aspects
- Use a hierarchy of agents
  - Decouple low level analysis from user output
  - Data acquisition to decision-support
  - Can add analysis or other agent functions as needed
  - Low-level agents can be developed and refined in parallel because they are independent
- Complexity of knowledge bases increases as ascend the hierarchy of intelligent agents
  - Knowledge base structure tied to reasoning system
- Any reasoning system can be chosen for an agent

Conclusion and Future Work

- Intelligent agents may be able to improve situational awareness in cyber and real space
- To move towards ubiquitous intelligent agent assistance, we proposed an approach for knowledge base development
    - Enables separate development of knowledge base for each intelligent agent
    - Supports rapid, successive refinement as well as individual performance testing
- Plan to create scenario development and evaluation guidelines
- Plan to tackle the group situational awareness problem